Appendix F

BMP Matrix

Table G-1 MDOT Approved BMP Matrix

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Infiltration - a family of treatment systems in which the majority of the runoff from small storms is infiltrated in the ground rather than discharged into a surface water body. (1)					
Infiltration Trench - is an excavated trench (3 to 12 feet deep), backfilled with stone aggregate, and lined with filter fabric. (23) It is used to treat a small portion of the runoff by detaining storm water for short periods until it percolates down to the groundwater table. (21) Useful life is usually around 10 years. (20)	*potential loss of infiltrative capacity. (1) *applicability depends on specific site characteristics/opportunities (slope, soil types, proximity to water table). (23) *potential groundwater contamination. (1) *not suitable for sites that contain chemical or hazardous material. (23) *may need to be preceded by appropriate pretreatment. (23) *relatively short life span. (23)	*efficient removal of pollutants. (1) *can recharge groundwater supplies. (2) *provides localized streambank erosion control. (2) *easy to fit into unutilized areas of development sites. (2) *an effective runoff control. (1) *increases baseflow in nearby streams. (23) *Low land use requirement. (20)	* nitrogen compounds 40% to 80%. (2) * phosphorus compounds 40% to 80%. (2) * combined nitrogen and phosphorus compounds 45% to 75% (depending on design). (8) * total suspended solids 75%. (20) *total phosphorous 60%. (20) * total nitrogen 55%. (20) *COD 65%. (20) * Lead 65%. (20) * Zinc 65%. (20)	* $4,900/acre (prorated using ENR index from 1992 cost). (5) * $3.6 to $10.70/cubic feet storage (prorated using ENR index from 1986 cost). (20)	* $1,800/acre/year (prorated using ENR index from 1992 cost). (5) * 9% of Capital Cost (20)

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Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Pond (Basin) - consist of shallow, flat basins excavated in pervious ground, with inlet and outlet structures to regulate flow. (19) Useful Life is usually around 25-years. (20)	*potential loss of infiltrative capacity. (1) *low removal of dissolved pollutants in very coarse soils. (1) *possible nuisance (odor, mosquito). (2) *frequent maintenance requirement. (2) *risk of groundwater contamination. (1) * High land use requirement. (20)	*achieves high levels of particulate pollutant removal. (1) * can recharge groundwater supplies. (2) *an effective runoff control. (1) *can serve tributary areas up to 50 acres. (1) *provides localized streambank erosion control. (2) *cost effective. (2)	* nitrogen compounds 40% to 80%. (2) * phosphorus compounds 40% to 80%. (2) * combined nitrogen and phosphorus compounds 45% to 75% (depending on design). (8) * total suspended solids 75%. (20) *total phosphorous 65%. (20) * total nitrogen 60%. (20) *COD 65%. (20) * Lead 65%. (20) * Zinc 65%. (20)	* $36,900/million gallons (prorated using ENR index from 1992 cost). (5) * $0.60 to $1/cubic feet storage (prorated using ENR index from 1986 cost). (20)	* $1,200/million gallons/year (prorated using ENR index from 1992 cost). (5) * 7% of Capital Cost (20)
Concrete Grid Pavement – are lattice grid structures with grassed or pervious material placed in the grid openings. (1) Useful life is usually around 20 years. (20)	*require regular maintenance. (20) *not suitable for high traffic areas. (20) *potential groundwater contamination. (20) *only feasible where soil is permeable. (20)	*groundwater recharge. (20) *can provide peak flow control. (20)	*total nitrogen 90%. (20) * total phosphorus compounds 90%. (20) * total suspended solids 90%. (20) *COD 90%. (20) * Lead 90%. (20) * Zinc 90%. (20)	* $1.7 - $3.5/$ft^2$ (prorated using ENR index from 1981 cost) (incremental cost beyond the conventional asphalt pavement) (20)	* -$0.07/$ft^2$ feet (prorated using ENR index from 1981 cost) (incremental cost beyond the conventional asphalt pavement) (20)
Infiltration Drainfields – a system composed of a pretreatment structure, a manifold system, and a drainfield. (28)	*high maintenance when sediment loads are heavy. (28) *short life span if not well maintained. (28) *not suitable in regions with clay or silty soils. (28) *anaerobic conditions could clog the soil. (28) *potential groundwater contamination. (28)	*groundwater recharge. (28) *used to control runoff. (28)	* depends on design – little monitoring data currently available. Potentially 100% of pollutant could be prevented from entering surface water. (28)	Approx. $72,000 for a drainfield with dimensions: 100 ft long, 50 feet wide, 8 feet deep with 4 ft cover. (28)	

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Wetlands - constructed wetlands are a single stage treatment system consisting of a forebay and micro pool with aquatic plants. They remove high levels of particulate, as well as some dissolved contaminants. (19) Useful life is around 50 years. (20)	*need of supplemental water to maintain water level. (1) *potential nutrient release in the winter. (19) *reduction in hydraulic capacity with plant growth. (19) *wetland area less than 2% of watershed area. (10) *potential groundwater contamination. (26) * high land requirements. (20)	*passive recreation and wildlife support. (1) *improve downstream water and habitat quality. (26) *flood attenuation. (26) *achieves high levels pollutant removal. (1)	* total suspended solids 67% (26) & 65% (20). * total phosphorus 49% (26) & 25% (20). * total nitrogen 28% (26) & 20% (20). * organic carbon 34%. (26) * COD 50%. (20) * petroleum hydrocarbons 87%. (26) * cadmium 36%. (26) * copper 41%. (26) * lead 62% (26) & 65% (20). * zinc 45% (26) & 35% (20). * bacteria 77%. (26)	$26,000 to $55,000 per acre of wetland. (26)	2 percent of construction cost per year. (26)
Biofilters - Systems designed to pass storm water runoff slowly over a vegetated surface in the form of a swale or strip to filter pollutants and to infiltrate the runoff. (19)					

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Vegetated Swale – is a broad, shallow channel (typically trapezoidal shaped) with a dense stand of vegetation covering the side slopes and bottom. (29) Useful life is around 50 years. (20)	*generally incapable of removing nutrients. (2) *can become drowning hazards, mosquito breeding areas. (29) *not appropriate for steep topography, very flat grades. (29) *tributary area limited to a maximum of 5 acres. (19) *difficult to avoid channelization. (19) *ineffective in large storms due to high velocity flows. (29)	*design to convey runoff of 2 year storm, with freeboard of 10 year storm. (19) * low land requirement. (20) *suitable for small residential areas. (1) *can removes particulate pollutants at rates similar to wet ponds. (1) *reduction of peak flows. (29) *lower capital cost. (29) *promotion of runoff infiltration. (29) * low land requirements. (20)	* nitrogen 0 to 60% (2) * total nitrogen 10%. (20) * phosphorus 0 to 60% (2) * total phosphorus 9% (29) & 20% (20). * COD 25%. (20) * oxygen demanding substances 67%. (29) * total suspended solids 81% (29) & 60% (20). * nitrate 38%. (29) * hydrocarbons 62%. (29) * cadmium 42%. (29) * lead 67% (29) & 70% (20). * zinc 71% (29) & 60% (20). * copper 51%. (29)	* $6.80 to $12.50 per linear foot (prorated using ENR index from 1987 cost). (29) * $10.80 to $63.40 per linear foot (prorated using ENR index from 1991 cost). (29) * typical total for a 1.5 ft. deep, 10 ft wide, 1,000 ft long Low - $8,100 Moderate - $14,870 High - $21,640 Prorated using ENR index from 1991 cost). (29)	* $0.73 - $0.95 per linear foot (prorated using ENR index from 1991 cost). (29) * $1/linear foot 9prorated using ENR index from 1987 cost). (20)
Infiltration (Vegetative Filter) Strip - are broad surfaces with a full grass cover that allows storm water to flow in a relatively thin sheets (21) Useful life is around 50 years (20).	*sheet flow may be difficult to attain. (1) *not appropriate for steep slopes. (19) *tributary area limited to 5 acres. (19)	*suitable for parking lots. (1) *slows runoff flow. (1) *removes particulate pollutants. (1)	* nitrogen 0 to 40%. (2) * phosphorus 0 to 40%. (2) * total suspended solids 65%. (20) * total phosphorous 40%. (20) * total nitrogen 40%. (20) * COD 40%. (20) * lead 45%. (20) * zinc 60%. (20)	* $3,100/acre (prorated using ENR index from 1992 cost). (5)	* $310/acre/yr (prorated using ENR index from 1992 cost). (5) * $139 to $1,100/acre/year (prorated using ENR index from 1987 cost). (20)

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Dry Detention Basins - consist of a settling basin with an outlet sized to remove particulate matter by slowly releasing accumulated runoff over a 24 to 40 hour period. "Dry" detention basins may be designed to empty between usages. (19) Useful life is usually 50 years. (20)	*occasional nuisance in inundated portion. (19) *inability to vegetation may result in erosion and re-suspension. (1) *limited orifice diameter preclude use in small watersheds. (1) *requires differential in elevation at inlet and outlet. (1) *frequent sediment maintenance. (19) * High land requirement. (20)	*creation of local wildlife habitat. (2) *recreational use in inundated portion. (2) *can remove soluble nutrients by shallow marsh or permanent pool. (2) *suitable for sites over 10 acres. (10) *temporary storage of runoff. (1) *no need of supplemental water. (1) *protection for downstream channel erosion. (2)	* nitrogen 20% to 60%. (2) * phosphorus 20% to 80% (2) & 10% to 30%. (10) * nitrogen and phosphorus 30% to 70% (depending on volume ratio). (8) * soluble nutrients – low or negative. (10) * total suspended solids 45% (20) & 88% (44). * nitrate 15% (44). * nitrite 61% (44). * oil and grease 56%. (44) * fecal coliform 45%. (44) total petroleum hydrocarbons 17% to 20%. (44) * TKN 40%. (44) * ammonia 5%. (440 *total phosphorous 25% (20) & 57% (44). * total nitrogen 30%. (20) *COD 20% (20) & (44). * lead 20% (20) & 55% (44). * zinc 20% (20) & 47% (44). * chromium 68%. (44) * copper 37%. (44) * nickel 62%. (44)	$123,000/million gallons (prorated using ENR index from 1992 cost). (5)	* $1,230/million gallons/year (prorated using ENR index from 1992 cost). (5) * 4% of capital cost. (20)

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Catch Basin Inlet Devices - devices that are inserted into storm drain inlets to filter or absorb sediment, pollutants, and oil and grease (21)	* not feasible for larger than 5 acres. (20)	* high removal efficiency for large particles and debris for pretreatment. (20) * low land requirement. (20) * flexibility for retrofit of existing systems. (20)			
Curb Inlet Drain Diaper Insert – sorbent type diaper placed at the catch basin insert. (40)				$125 per unit. (40)	
Some Examples of Temporary Erosion and Sediment Control BMPs – (typically used during construction activity)					

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Temporary Seeding of Stripped Areas - The establishment of a temporary vegetative cover on disturbed areas by seeding with rapidly growing plants. This provides temporary soil stabilization to areas which would remain bare for more than seven days where permanent cover is not necessary or appropriate. (42)	*Temporary seeding is only viable when there is a sufficient window in time for plants to grow and establish cover. During the establishment period the bare soil should be protected with mulch and/or plastic covering. (42) *If sown on subsoil, growth may be poor unless heavily fertilized and limed Because over-fertilization can cause pollution of stormwater runoff, other practices such as mulching alone may be more appropriate. The potential for over-fertilization is an even worse problem in or near aquatic systems. (42) *Once seeded, areas cannot be used for heavy traffic. (42) *May require regular irrigation to flourish. Regular irrigation is not encouraged because of the expense and the potential for erosion in areas that are not regularly inspected. The use of low maintenance native species should be encouraged, and planting should be timed to minimize the need for irrigation. (42)	*This is a relatively inexpensive form of erosion control but should only be used on sites awaiting permanent planting or grading. Those sites should have permanent measures used. (42) *Vegetation will not only prevent erosion from occurring, but will also trap sediment in runoff from other parts of the site. (42) *Temporary seeding offers fairly rapid protection to exposed areas. (42)			

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Mulching and Matting - Application of plant residues or other suitable materials to the soil surface. This provides immediate protection to exposed soils during the period of short construction delays, or over winter months through the application of plant residues, or other suitable materials, to exposed soil areas. Mulches also enhance plant establishment by conserving moisture and moderating soil temperatures. Mulch helps hold fertilizer, seed, and topsoil in place in the presence of wind, rain, and runoff and maintains moisture near the soil surface. (42)	*Care must be taken to apply mulch at the specified thickness, and on steep slopes mulch must be supplemented with netting. (42) *Thick mulches can reduce the soil temperature, delaying seed germination. (42)	*Mulching offers instant protection to exposed areas. (42) *Mulches conserve moisture and reduce the need for irrigation. (42) *Neither mulching nor matting require removal; seeds can grow through them unlike plastic coverings. (42)			
Spill Response and Prevention Plan (46)	*Requires a well-planned and clearly defined plan. *May require training *Equipment must be readily available. (46)	*can be highly effective at reducing the risk of surface and ground water contamination. (46)	N/A	No Information	No Information
Used Oil Recycling Program (46)	*Oil may easily become contaminated during collection making it a hazardous waste. (46)	*reduces the risk of groundwater and surface water contamination, but can become hazardous waste if mixed with other materials. (46)	N/A	N/A	Recovery service charge $79-$179 (46)
Materials Management Plan (46)	No Information	*Identifies hazardous and non-hazardous materials in the facility. (46) *Assures that all containers have labels. (46) *Identifies hazardous chemicals that require special handling, storage, and disposal (46)	N/A	No Information	No Information

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Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
BMP Inspection and Maintenance Plan (46)	Materials needed for emergency structural repairs may not be easily obtainable and may require stockpiling. (46)	*A regular inspection and maintenance program will maintain the effectiveness and structural integrity of the BMPs. (46)		N/A	$150-$9,000 depending on the BMP. (46)
Storm Drain Stenciling (46)	*Paint will weather away a short period of time and decals may need replaced if vandalized or improperly installed. (46)	*Educates the general public that the storm drain discharges into a natural waterbody. (46)	N/A	Mylar Stencils- $0.45 per lineal inch (46) Ceramic tiles $5-$6 each (46) Metal stencils- $100 or more (46)	No Information
Green Parking (46) This BMP will be experimental for MDOT until it is proven valuable and cost effective.	*Applicability(46) *Cost *Maintenance	*Promotes infiltration and filtering of Stormwater. (46)	N/A	No Information	No Information
Alum Injection (46) This BMP will be experimental for MDOT until it is proven valuable and cost effective.	*Experimental practice(46) *Involves on-going operation in addition to maintenance(46) *Does not control flows(46) *Chemicals may have negative impacts downstream(46) *Precipitates must be disposed of. (46)	*Alum injected into stormwater forms precipitates that combine with heavy metals and phosphorus creating a floc. The floc is inert and stable. (46)	Removal efficiency varies greatly by study and pollutant. The removal efficiency is uncertain at this time. (46)	Cost ranges from $135,000 to $400,000 depending on the size of the watershed. (46)	$6,500 to $25,000 (46)

Nationwide Examples of Treatment Control (Structural) Best Management Practices (BMPs)					
Treatment Control (Source)	Limitations	Benefits	Removal Efficiency	Capital Cost (approximate)	O & M Cost (approximate)
Plastic Covering - The covering with plastic sheeting of bare areas, which need immediate protection from erosion. This provides immediate temporary erosion protection to slopes and disturbed areas that cannot be covered by mulching, in particular during the specified seeding periods. Plastic is also used to protect disturbed areas, which must be covered during short periods of inactivity to meet November 1 to March 31 cover requirements. Because of many disadvantages, plastic covering is the least preferred covering BMP. (42)	*There can be problems with vandals and maintenance. (42) *The sheeting will result in rapid, 100 percent runoff, which may cause serious erosion problems and/or flooding at the base of slopes unless the runoff is properly intercepted and safely conveyed by a collecting drain. This is strictly a temporary measure, so permanent stabilization is still required. *The plastic may blow away if it is not adequately overlapped and anchored. (42) *Ultraviolet light can cause some types of plastic to become brittle and easily torn. (42) *Plastic must be disposed of at a landfill; it is not easily degradable in the environment. (42)	*Plastic covering is a good method of protecting bare areas, which need immediate cover and for winter plantings. (42) *May be relatively quickly and easily placed. (42)			

Nationwide Examples of Source Control (Non-Structural) Best Management Practices (BMPs)

Source Control (5)	Benefit (5)	Capital Cost (5)	O & M Cost (5)
Minimizing Effects from Highway Deicing			
Employee Training – teaches employees about storm water management, potential sources of contaminants, and BMPs. (43)	*low cost and easy to implement storm water management BMPs. (43)		
Litter Control	*Reduce potential clogging. *proper disposal of paper, plastic and glass.	$20 per trash cans (1992)	$16/acre/yr (1992)
Identify and Prohibit Illegal or Illicit discharge to Storm Drain	*halt hazardous and harmful discharge.	$2/acre (assumes 1 system monitored every 5 sq. miles)	$50/acre/yr (assumes TV inspection)
Street Sweeping - Two types of street sweepers are available for removal of solids from highway surfaces. The commonly used design is a mechanical street cleaner that combines a rotating gutter broom with a large cylindrical broom to carry the material onto a conveyor belt and into a hopper. The vacuum assisted sweepers, found to potentially remove more fine particles from the impervious surface, are impracticable due to their slow speed in highway maintenance operations. (42)	*reduction in potential clogging storm drain material. *some oil and grease control.	N/A	$0.83/acre/yr
Clean and Maintain Storm Drain Channels	*prevent erosion in channel. *improve capacity by removing sedimentation. *remove debris toxic to wildlife.	N/A	$21/acre/yr
Clean and Maintain Storm Inlet and Catch Basins - Inlets, catch basins, and manholes are to be periodically inspected and cleaned out using a vacuum truck. (42)	*removes sedimentation. *may prevent local flooding.	N/A	$21/acre/yr

Snow and Ice Control Operations - Snow control operations consist of removing accumulated snow from the traveled way, shoulders, widened areas and public highway approaches within the right-of-way. (42)	*removes snow/ice before it requires ice control operations. (42)		